Claims

What is claimed is:

1. A valve, comprising:

an actuator comprised of a piezoelectric device comprising one or more prestressed electroactive benders;

a member operatively connected to the actuator;

a contact surface, wherein the member is operable to move relative to the contact surface and to contact the contact surface; and

a control system operatively connected to the actuator for determining a position of the member relative to the contact surface.

2. The valve, as set forth in claim 1, wherein the control system comprises:

an actuator control circuit operatively connected to the actuator and operable to apply a control signal to the actuator, the control signal controlling movement of the member relative to the contact surface, and operable to receive an output from the actuator; and

a seat detection circuit operatively connected to the actuator control circuit and operable to determine contact of the member with the contact surface from the output.

3. The valve, as set forth in claim 2, wherein the output comprises a voltage produced by the actuator.

4. The valve, as set forth in claim 3, wherein the seat detection circuit determines a rate of change of the output.

5. The valve, as set forth in claim 4, wherein the seat detection circuit determines contact of the member with the contact surface from a comparison of the rate of change of the output to a predetermined value.

6. A valve, comprising:

an actuator comprised of a piezoelectric device comprising one or more prestressed electroactive benders;

a member operatively connected to the actuator;

a contact surface, wherein the member is operable to move relative to the contact surface and to contact the contact surface; and

a control system operatively connected to the actuator for controlling the velocity of the member relative to the contact surface.

7. The valve, as set forth in claim 6, wherein the control system comprises:

an actuator control circuit operatively connected to the actuator and operable to apply a control signal to the actuator, the control signal controlling movement of the member relative to the contact surface, and operable to receive an output from the actuator;

a seat detection circuit operatively connected to the actuator control circuit and operable to determine contact of the member with the contact surface from the output; and

a velocity control circuit operatively coupled to the actuator control circuit and to the seat detection circuit and operable to provide an input to the actuator control circuit for controlling the velocity of the member.

8. The valve, as set forth in claim 7, further comprising:

a position control circuit operatively connected to the actuator control circuit, the seat detection circuit, and the velocity control circuit, the position control circuit having a stored charge value and a current charge value.

9. The valve, as set forth in claim 8, wherein the position control circuit determines a charge error as a function of the stored charge value and the current charge value.

10. The valve, as set forth in claim 9, wherein the velocity control circuit determines the input as a function of the charge error.

11. The valve, as set forth in claim 8, wherein the position control circuit includes an integrator operable to integrate current flowing through the actuator during a current actuation cycle to determine the current charge value.

12. The valve, as set forth in claim 11, wherein the stored charge value is determined by the seat detection circuit during a prior actuation cycle.

13. An apparatus for determining position of a valve member relative to a valve contact surface, wherein the member is operatively connected to an actuator, comprising:

an actuator control circuit operatively connected to the actuator and operable to apply a control signal to the actuator, the control signal controlling movement of the member relative to the contact surface, and operable to receive an output from the actuator; and

a seat detection circuit operatively connected to the actuator control circuit and operable to determine contact of the member with the contact surface from the output;

wherein the actuator is a piezoelectric device.

14. The apparatus, as set forth in claim 13, wherein the output comprises a voltage produced by the actuator.

15. The apparatus, as set forth in claim 14, wherein the seat detection circuit determines a rate of change of the output.

16. The apparatus, as set forth in claim 15, wherein the seat detection circuit determines contact of the member with the contact surface from a comparison of the rate of change of the output to a predetermined value.

17. An apparatus for controlling velocity of a valve member relative to a valve contact surface, wherein the member is operatively connected to an actuator, comprising:

an actuator control circuit operatively connected to the actuator and operable to apply a control signal to the actuator, the control signal controlling movement of the member relative to the contact surface, and operable to receive an output from the actuator;

a seat detection circuit operatively connected to the actuator control circuit and operable to determine contact of the member with the contact surface from the output; and

a velocity control circuit operatively coupled to the actuator control circuit and seat detection circuit and operable to provide an input to the actuator control circuit for controlling velocity of the member;

wherein the actuator is a piezoelectric device.

18. The apparatus, as set forth in claim 17, further comprising:

a position control circuit operatively connected to the actuator control circuit, the seat detection circuit, and the velocity control circuit, the position control circuit having a stored charge value and a current charge value.

19. The apparatus, as set forth in claim 18, wherein the position control circuit determines a charge error as a function of the stored charge value and the current charge value.

20. The apparatus, as set forth in claim 19, wherein the velocity control circuit determines the input as a function of the charge error.

21. The apparatus, as set forth in claim 18, wherein the position control circuit includes an integrator operable to integrate current flowing through the actuator during a current actuation cycle to determine the current charge value.

22. The apparatus, as set forth in claim 21, wherein the stored charge value is determined by the seat detection circuit during a prior actuation circuit..

23. A method of determining position of a valve member relative to a valve contact surface, wherein the member is operatively connected to an actuator comprised of a prestressed electroactive bender, comprising:

applying a control signal to the actuator to cause the member to move relative to the contact surface;

determining an output of the actuator; and

determining contact of the member with the contact surface from the output.

24. The method, as set forth in claim 23, further comprising:

comparing the output to a predetermined value to determine contact of the member with the contact surface.

25. A method of controlling velocity of a valve member relative to a valve contact surface, wherein the member is operatively connected to an actuator comprised of a prestressed electroactive bender, comprising:

storing an output of the actuator in a prior actuation cycle;

determining an output of the actuator in a current actuation cycle; and

modifying the velocity of the member as a function of the stored and current outputs.

26. The method, as set forth in claim 25, wherein the modifying step further comprises:

comparing the current output and the stored output to generate a control signal representing a desired change in charge on the actuator; and

applying the control signal to the actuator to control the velocity of the member,

wherein the stored output indicates a seated position of the member during the prior actuation cycle.